Treatment Options for Arsenic Trioxide Bearing Dust at the Giant Mine, Yellowknife, Northwest Territories, Canada

N. A. Thompson and S. R. Schultz[1]
Department of Indian Affairs and Northern Development, Government of Canada
Box 1500, Yellowknife, Northwest Territories, Canada, X1A 2R3
T: 867-669-2434, F: 867-669-2439, E: thompsonn@inac.gc.ca
[1]SRK Consulting Inc.

Background

The Giant Mine, located in Yellowknife, Northwest Territories, Canada, has been operating as a gold mine since 1948. Refractory ore, containing arsenopyrite, was mined from underground and roasted to facilitate the recovery of gold. The roasting process produced arsenic trioxide bearing dust as a waste product, which was placed into underground storage chambers at a rate of 10-13 tons per day. Fifty years of operation have resulted in approximately 265,000 tons of arsenic trioxide bearing dust, stored in 15 underground chambers.

In 1999, Royal Oak Mines Inc., the owner of Giant Mine, was placed in receivership and the property was purchased by an existing Yellowknife mine operator. As a result, roasting operations were shut down and Giant ore is now being processed at another local mine. In order to effect the sale, the federal government assumed liability for the pre-existing conditions of the site, including the arsenic trioxide bearing dust stored underground. The mine is located within city limits, and potentially significant environmental, public health and safety concerns exist.

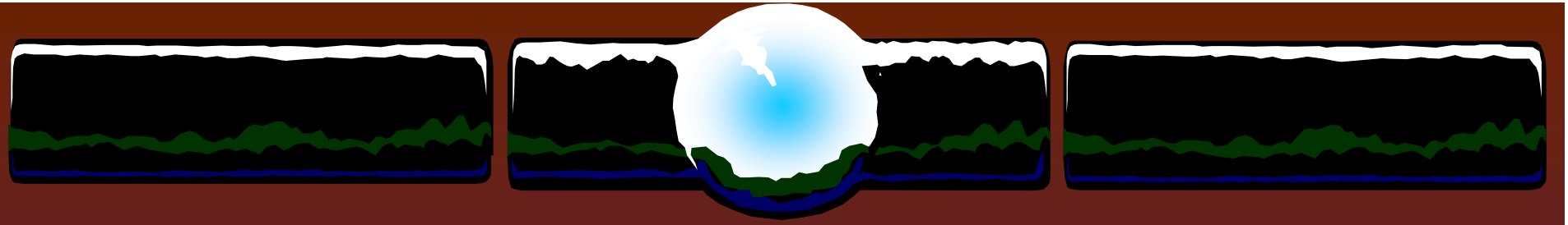
Project Management

The Department of Indian Affairs and Northern Development, in its role as regulator and project manager, has been working independently, and with the mine's current owner, to assess options for managing the dust stored underground. Research has been initiated into: the hydrogeology and geochemistry of the mine; options for permanent underground storage (freezing technology, in-situ stabilization, preferential groundwater pathways); methods of extracting dust from the underground chambers; material re-processing for arsenic and gold recovery (hot water leach or sublimation); arsenic chemical stabilization (ferric arsenate using autoclave); and solidification/encapsulation (glass, bitumen or cement). By October 2001, the MacKenzie Valley Land and Water Board requires the submission of a Project Description outlining an arsenic trioxide management plan for the dust stored underground.

This presentation will examine the activities undertaken and issues faced in evaluating treatment processes for the Giant Mine arsenic trioxide project.

References

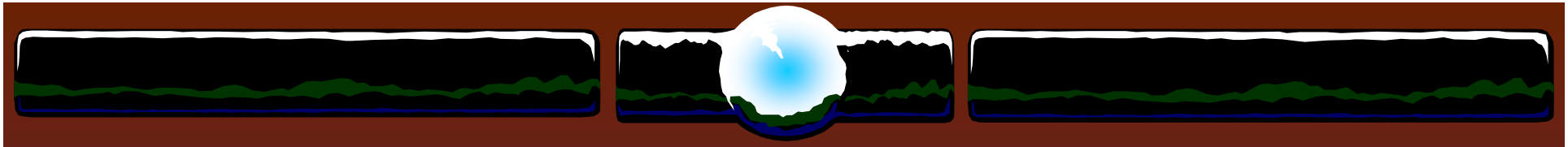
-Giant Mine Arsenic Trioxide Management: Technical Meeting Proceedings. INAC. October 1997.
-Arsenic Trioxide Management Feasibility Study. Prepared for INAC by Dillon Consulting Limited. October 1997.
-Giant Mine - Arsenic Trioxide Management. Royal Oak Mines Inc. March 1998.
-Arsenic Technology Review - Update. Prepared for INAC by Dillon Consulting Ltd. January 1999.
-Giant Mine Arsenic Trioxide Technical Workshop, Dillon Consulting Ltd. November 1999.
-Senior Technical Session, Giant Mine Arsenic Trioxide, SRK Consulting. August 2000.



Treatment Options for Managing Arsenic Trioxide Bearing Dust at the Giant Mine

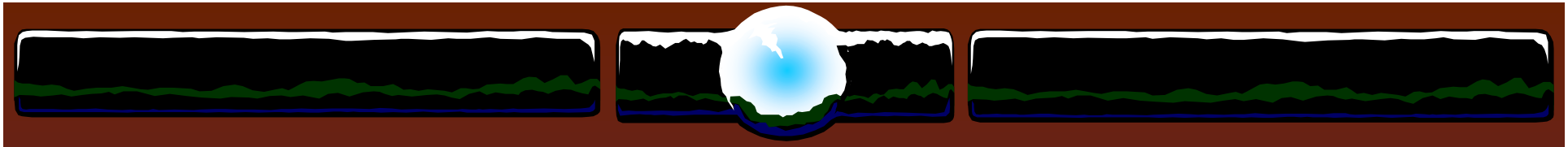
USEPA Workshop on Managing Arsenic Risks in the Environment

May, 2001



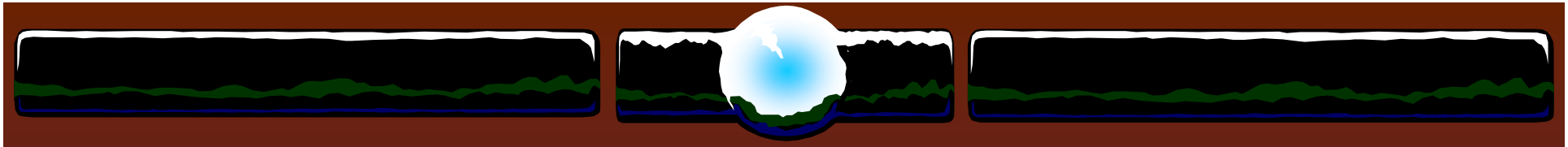
BACKGROUND

- Gold mine operating since 1948
- Located in Yellowknife, NWT
- 62º latitude in discontinuous permafrost
- 265,000 tons of arsenic trioxide dust (As_2O_3) stored underground (15 chambers)
- DIAND is the primary federal agency in the north



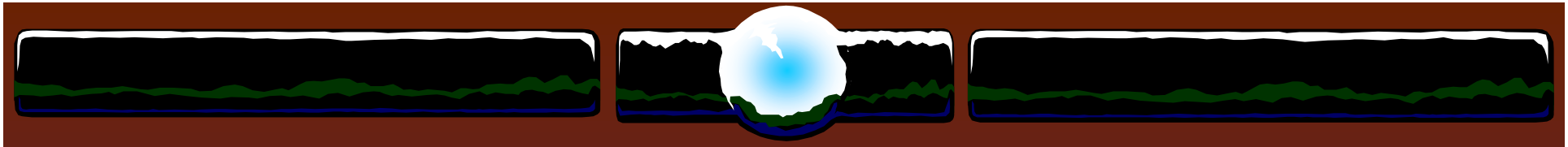
OWNERSHIP

- Royal Oak Mines Inc. was a mid-level mining company
- Amassed debts of $600 million and declared insolvent
- Court transfer to DIAND representing the federal government (1999)
- Sale to Miramar Giant Mine Limited (MGML) (1999)



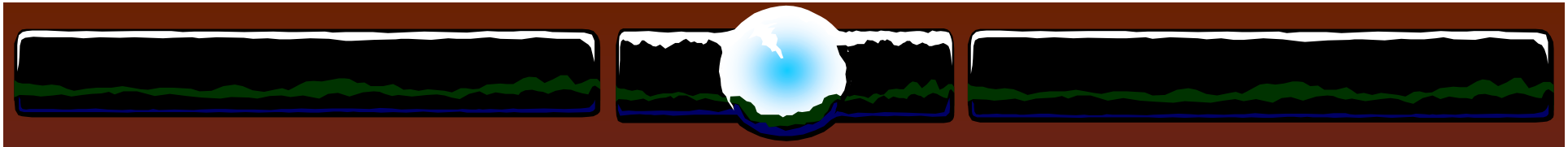
TERMS OF SALE

- MGML to maintain property in regulatory compliance
- Reclamation security trust ($425,000)
- Limited liability for pre-existing state of property - DIAND liability
- Right of termination (December 14, 2001)
- Limited production - processing at Con Mine
- Permanent closure of roaster - no further production of As_2O_3



DIAND RESPONSIBILITIES

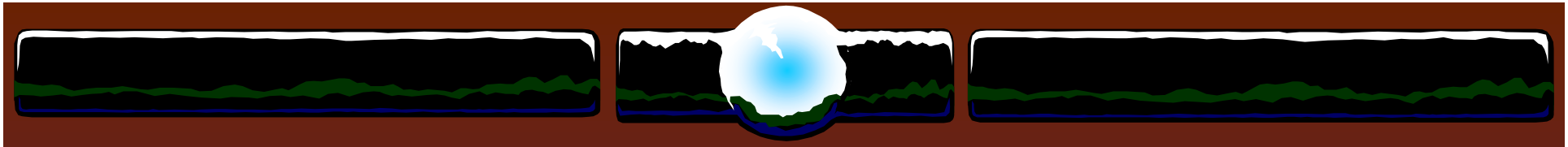
- Regulatory - NWT Waters Act - Inspector's Direction
- Operational / reclamation
  - As_2O_3 Management Project Description
  - Surface reclamation
  - Property management



As_2O_3 MANAGEMENT

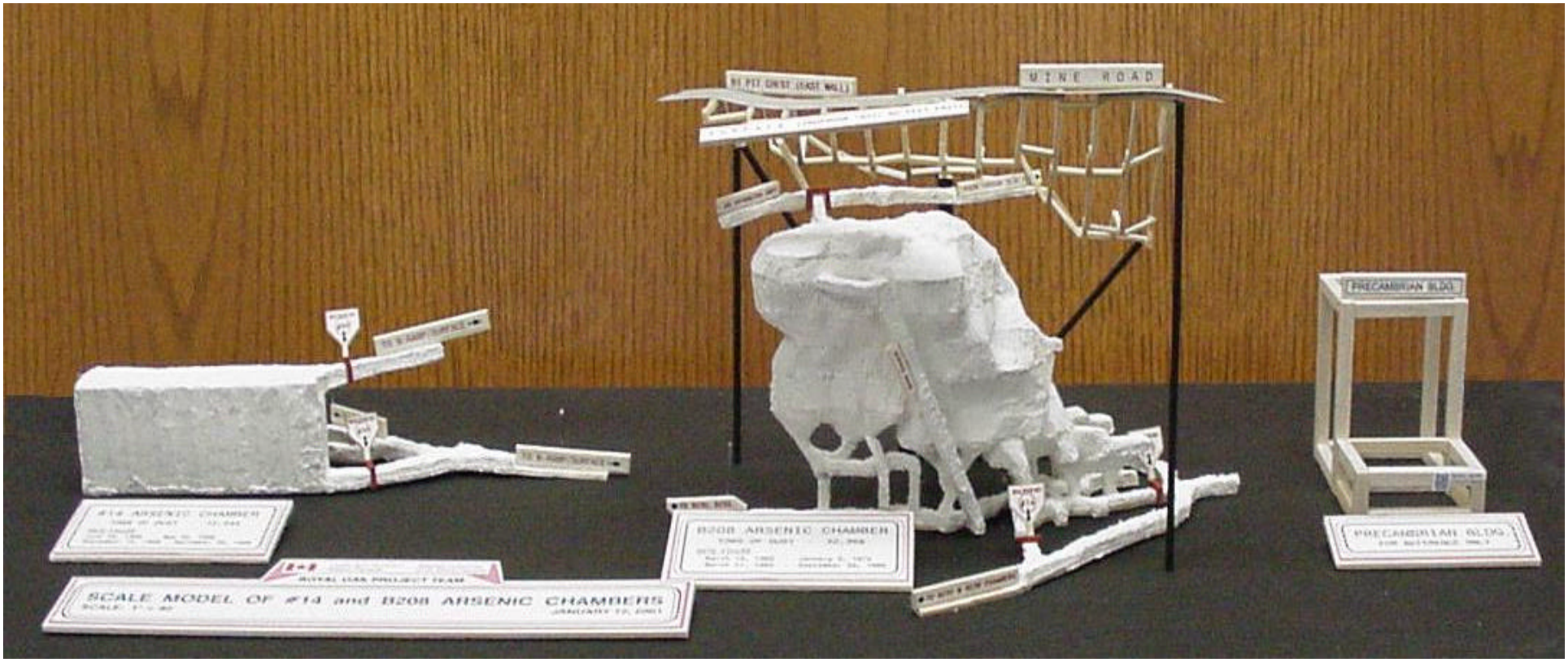
- *Objective: Determine best long term management option, obtain approvals & resources and implement*

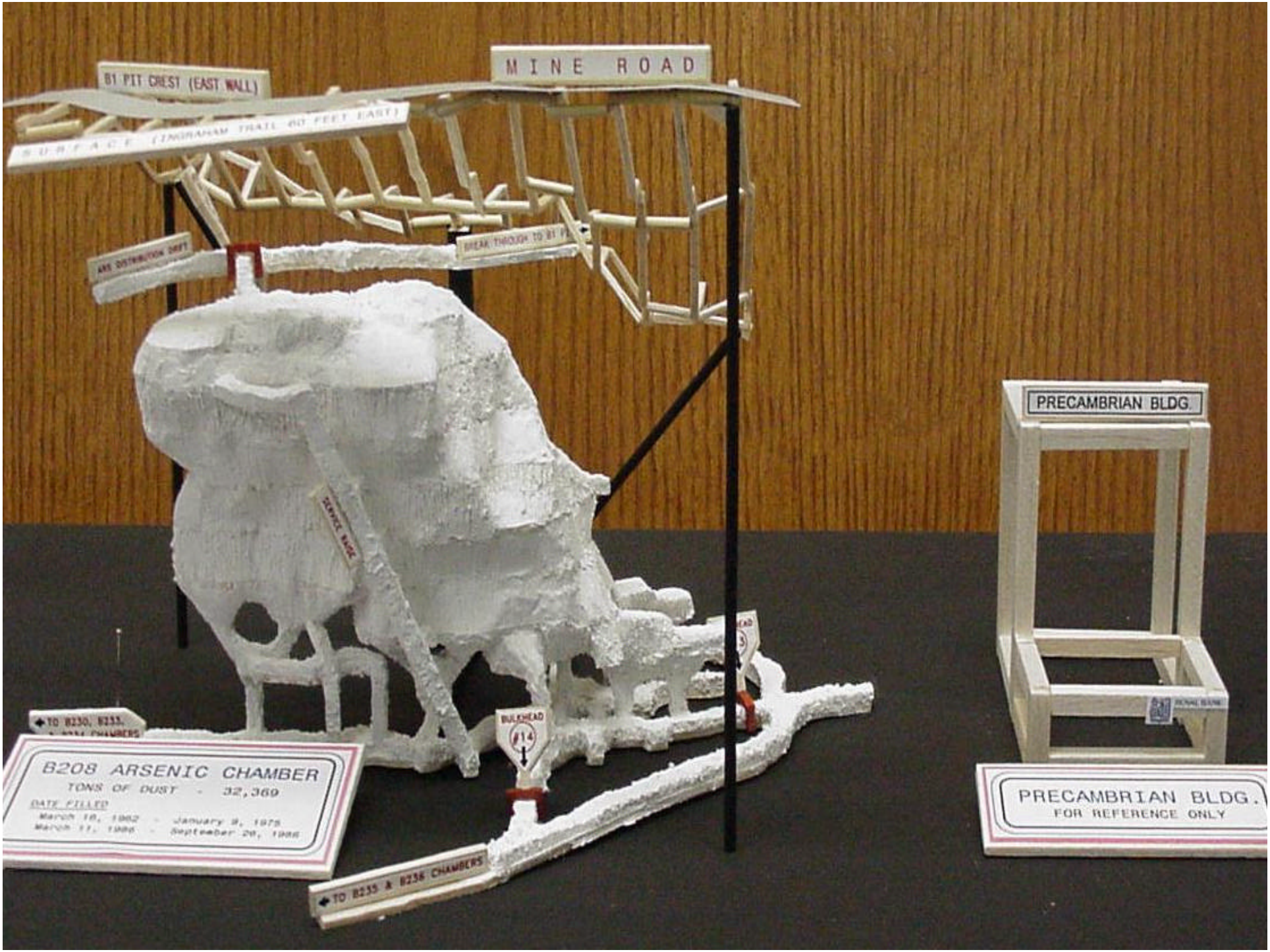
- *DIAND has undertaken significant research and assessment since 1997*
- *2 major Technical workshops in 1997 & 99 and a 3rd planned for 2001*

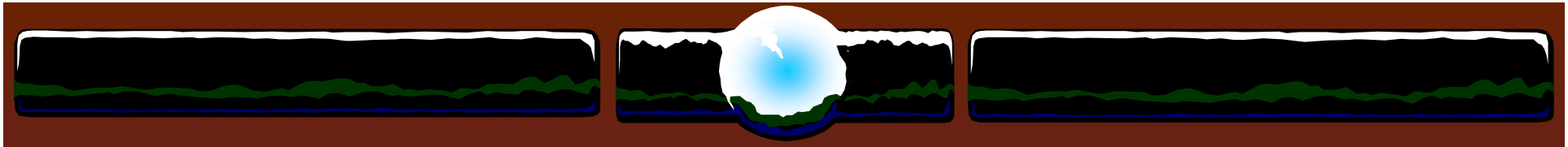


ARSENIC TRIOXIDE (As_2O_3)

- By-product of gold recovery – arsenopyrite ore
- Highly toxic, soluble
- 265,000 tons stored underground
  - assumptions – permafrost / low groundwater movement / competent host rock
- Located between 80' – 250' level in a 2000' mine
- Safely contained via mine dewatering and treatment
- Long-term management?


MINE ROAD
PRECAMBRIAN BLDG
B208 ARSENIC CHAMBER
SCALE MODEL OF #14 and B208 ARSENIC CHAMBERS


MINE ROAD
B1 PIT CREST (EAST WALL)
SURFACE (INGRAHAM TRAIL 60 FEET EAST)
ORE DISTRIBUTION DRIFT
BREAK THROUGH TO B1 PIT
SERVICE RAISE
BULKHEAD #14
TO B230, B233,
TO B233 & B236 CHAMBERS
B208 ARSENIC CHAMBER
TONS OF DUST - 32,369
DATE FILLED
March 18, 1962 - January 9, 1975
March 11, 1986 - September 28, 1986
PRECAMBRIAN BLDG.
PRECAMBRIAN BLDG.
FOR REFERENCE ONLY

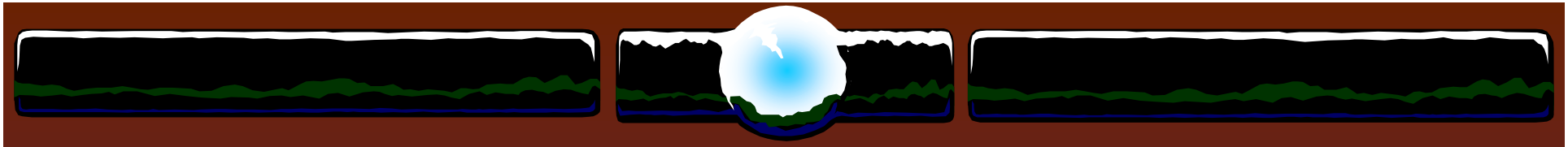


SHORT TERM
(maintain status quo)

- Ensure public health & safety and environmental protection
  - Ongoing monitoring of water - within and external to mine
  - Ongoing monitoring of As_2O_3 containment (bulkhead inspections)
  - Underground rehabilitation (access)
- As_2O_3 Management Project Description – MVLWB for October, 2001

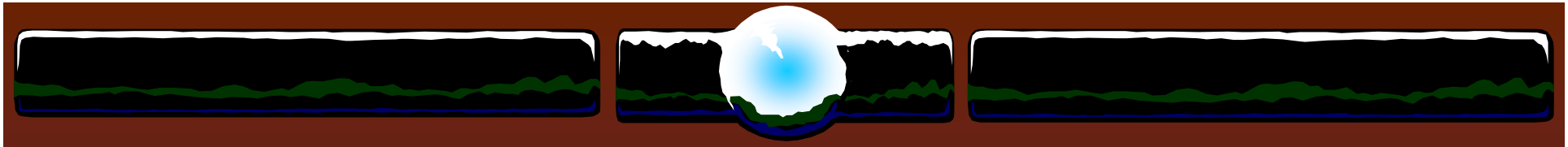

#50


#50



As_2O_3 MANAGEMENT OPTIONS

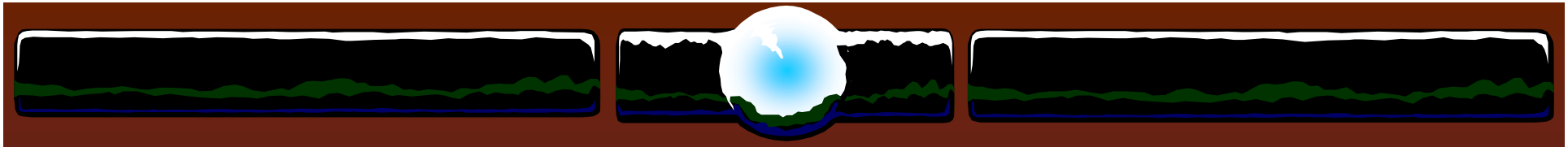
- Underground management
  - Pump & treat
  - Re-establishment of permafrost
  - Other containment options
- Extraction
  - Stabilization
    - Autoclave
    - Encapsulation
  - Purification & sale



LONG TERM

(develop As_2O_3 management plan)

- Detailed testing and evaluation
- Select long-term management option
- Prepare project description
- Submit proposal for environmental assessment and regulatory approvals
- Obtain authority/resources to proceed
- Implementation of approved management plan



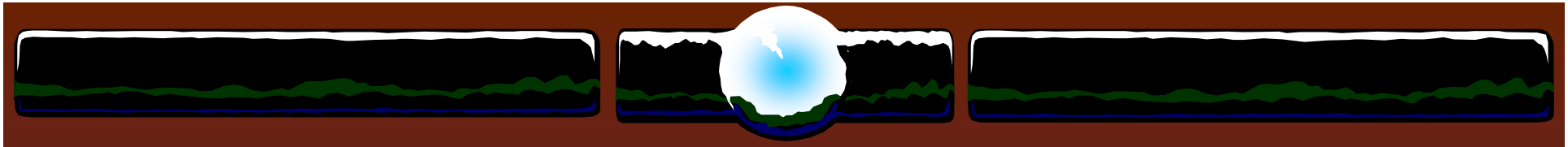
TIME LINE

- Phase I – Pre-feasibility Study (to June,2001)

  Objective: Identify most probable management options (3?) and obtain authority/resources to develop preferred option

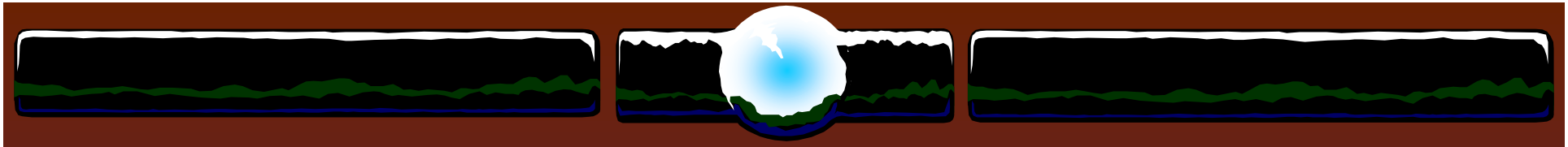
- *Phase II – Project Description (2001 – 2004)*

  Objective: Complete Project Description of best long-term management option and obtain approval to seek environmental assessment and regulatory approvals



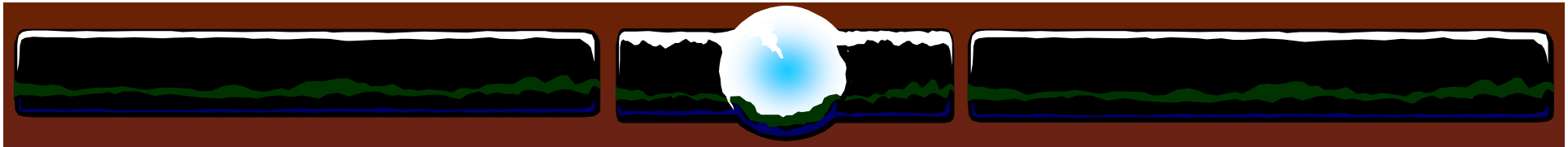
TIME LINE

- Phase III Environmental Assessment and Regulatory approvals (2004 – 2006)
  - Objective: Submit Project Description for Environmental Assessment and Licensing
- Phase IV: Implementation (2006 -)



ARSENIC TRIOXIDE DUST CONTENT

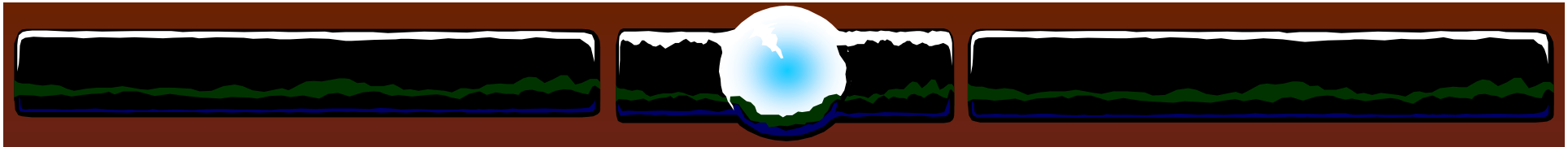
- Key chemical components of the dust (in wt %)
  - Arsenic: 36 – 67
  - Antimony: 0.30 – 2.13
  - Iron: 0.78 – 2.62
  - Gold: 2 – 80 (ppm) - averages 0.5 OPT
- Placed dry but issues with increasing density and moisture content



TREATMENT OPTIONS

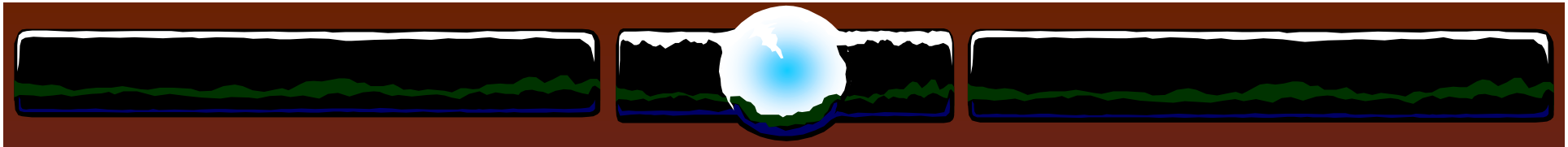
- 4 Categories
- Leave underground
  1) In-situ management
- Extraction to Surface
  2) Process to recover gold and arsenic
  3) Process to recover gold and stabilize arsenic
  4) Stabilize/solidification

- Waste Management



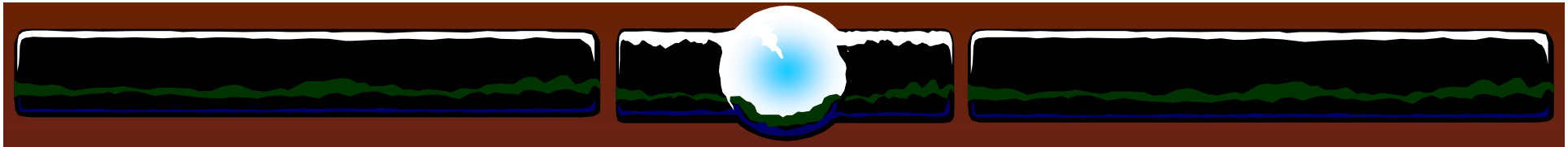
RECOVERY OF GOLD AND ARSENIC

- Fuming/Sublimation
  - 2 variations – “Warox” and “El Indio”
- Hot Water Leach
  - Atmospheric leach – Con Mine utilized
  - Pressure leach – Canmet researching
- Other Solvents
  - Methanol, ammonia, bromine



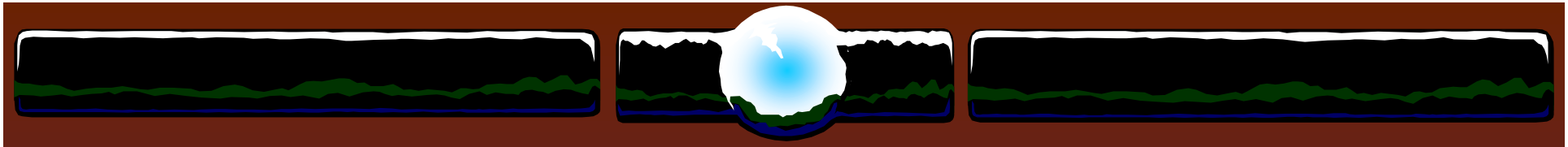
RECOVERY OF GOLD/STABILIZE ARSENIC

- Object is to produce stable ferric arsenate
- Pressurized process
  - Autoclave
- Atmospheric process
  - Bio-leaching



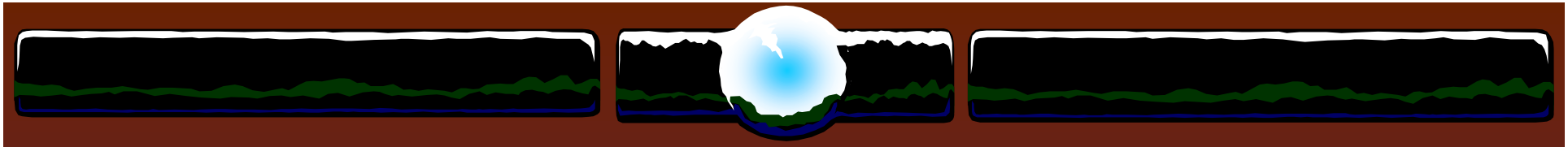
STABILIZATION/SOLIDIFICATION

- Concrete
  - Current data shows limited capacity & requires further testing. Look to data on incinerator fly ash solidification
- Bitumin
  - Concentrations of up to 40% with ongoing leachate testing
- Vitrification
  - This and bitumin have volatilization issues



WASTE MANAGEMENT

- All processes create waste streams
- Long term stability and leachate an issue
- Will most likely require treatment as a hazardous or special waste
- Will most likely require an engineered disposal facilities – liners, caps
- Volume creates logistical (size) considerations



CURRENT STATUS

- Pre-feasibility study near completion
- Rather than evaluating the range of options, first address the questions of the categories
- Address the environmental & health risks and cost factors between the categories
- Next tier of the Project Description/Feasibility Study will go into detail.
- Preparations underway for continued work